DEVELOPMENT OF RESIDENTIAL FLOOD DEPTH-DAMAGE CURVE FOR KUANTAN, PAHANG

MUHAMMAD AIMAN BIN MAT JAMIL

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : MUHAMMAD AIMAN BIN MAT JAMIL

ID Number : AA15129

Date :

DEVELOPMENT OF RESIDENTIAL FLOOD DEPTH-DAMAGE CURVE FOR KUANTAN, PAHANG

MUHAMMAD AIMAN BIN MAT JAMIL

Thesis submitted in partial fulfillment of the requirements
for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my academic supervisor, Dr. Noor Suraya Binti Romali who had taken a lot of efforts to meticulously go through my proposal and came up with helpful suggestion. She has always impressed me with her outstanding professional conduct, her strong conviction for science. I am truly grateful for her progressive vision about her tolerance for my naïve mistakes. I also sincerely thanks for the time spent proofreading and correcting my mistakes when doing this research.

Besides that, I would like to give my heartily thank to my member who have taken a lot of effort to go through my proposal and answering all my doubtful concern around proposal work. Many special thanks go to my coordinator for this research subject for providing a perfect guidance for us students to complete our studies.

Finally, I would like to express my heartfelt gratitude to my parents for their love, dream and sacrifice throughout my life. I acknowledge the sincerity of my parent, who consistently encouraged me to carry on my studies in Universiti Malaysia Pahang. I cannot find the appropriate words that could properly describe my appreciation for their support and faith in my ability to achieve my goals. Special thanks also should be given to all my friends that help me in my studies.

ABSTRAK

Pembangunan pesat dan pengurusan banjir yang tidak cekap adalah faktor utama kejadian banjir. Anggaran kerosakan banjir yang tepat diperlukan untuk memastikan pengurusan risiko banjir yang mampat. Banyak kajian tentang bahaya banjir telah dilakukan di kawasan yang rawan di Malaysia, namun, kajian tentang kerentanan akibat banjir adalah terhad terutama pada penilaian kerosakan. Oleh yang demikian, matlamat kajian ini adalah untuk menilai kerosakan banjir dan membangunkan lengkungan kerosakan kedalaman banjir untuk membantu penilaian risiko banjir di Kuantan, Pahang. Kajian ini memberi tumpuan kepada kawasan kediaman di Kuantan. Tinjauan temuduga telah dijalankan untuk mengumpul data kerosakan dan maklumat berkaitan mengenai banjir 2013 di Kuantan. Purata kerosakan isi rumah adalah RM 8,200 manakala purata kerosakan struktur adalah RM 2,200. Kerosakan struktur bagi rumah satu tingkat adalah sekitar RM 2,183 manakala purata kerosakan isi rumah adalah sekitar RM 8,062. Analisis regresi menunjukkan bahawa kerosakan kandungan dipengaruhi oleh jenis pekerjaan, dan bilangan tingkat bangunan manakala kerosakan struktur dipengaruhi oleh jenis bahan binaan dan jenis pekerjaan. Dengan R^2 0.92 untuk, keluk kerosakan kedalaman banjir yang diperolehi bagi kerosakan isi rumah adalah baik tetapi lengkung untuk kerosakan struktur adalah kurang memuaskan ($R^2 = 0.53$) disebabkan oleh pengumpulan data yang kurang baik. Keputusan yang diperoleh daripada kajian ini boleh digunakan untuk membantu perancangan pengurusan risiko banjir masa depan di kawasan kajian.

ABSTRACT

Rapid development and inefficient flood management is the main factor for the occurring of flood event. A precise estimation of flood damage is needed to ensure a compressive management of flood risk. Many studies on flood hazard had been done in prone area in Malaysia, however, the study on flood vulnerability is limited especially on damage assessment. Hence, the aim of this study is to assess the flood damage and to develop a flood depth-damage curve to assist in the assessment of flood risk in Kuantan, Pahang. This study is focusing on residential area in Kuantan. An interview survey was conducted to collect damage data and related information regarding the 2013 Kuantan flood. The average content damage is RM 8,200 while the average structural damage is RM 2,200. The average structural damage for single-storey house is around RM 2,183 while the average content damage is around RM 8,062. The regression analysis shows that the content damage is influenced by type of occupation, and number of storeys while the structural damage is influenced by the type of building material and type of occupation. With R^2 of 0.92 for content damage, the flood depth-damage curve obtained for is good enough but the curve for structural damage is poor (R^2=0.53) due to the poor quality of data collection. The results obtained from this study can be used to assist in the future flood risk management planning at the study area.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

R^2	Coefficient of determination

LIST OF ABBREVIATIONS

RM	Ringgit Malaysia
USD	United Stade Dollar
DID	Malaysian Drainage and Irrigation Department
HEC-RAS	Hydrologic Engineering Center- River Analysis System
ArcGIS	Geographic Information System
HEC-FDA	Hydrologic Engineering Center- The Flood Damage Reduction Analysis
HAZUS-MH	Hazus-Multi Hazard
FLEMO	Flood Loss Estimation Model
STATA	Statistical software (Statistic and Data)

CHAPTER 1

INTRODUCTION

1.1 Background of study

Floods are natural disasters that often hit our country especially in the East Coast states of Peninsular Malaysia which is Kelantan, Terengganu, and Pahang. Normally these states will experience the monsoon season at the end of each year. The heavy rain that occurred during the season caused floods in the area (Zaidi et al., 2014).

Floods occur as a result of drainage systems and sewers that are not able to accommodate the volume of excessive rainwater and take a long time to stop. Floods often hit low areas such as near the river. Lots of property destroyed as well as livestock and plants. Those involved like farmers will suffer a big loss. Floods can also be life-threatening. Many are drowning because of playing with the flood waters that flow. It's become more dangerous to people that do not know how to swim. A safety parameter has been taken to mitigate the damage caused by the flood in the future such as deepen the river since most of the floods occurred due to the ripening of the river.

The floods occurred mainly in the city due to the disposal of waste and industrial waste into rivers and ditches. To address this problem, awareness of the community should be disclosed so that these negative activities do not continue to be done such as having a river-loving campaign and so on. An effective flood mitigation measures has to be taken to overcome this flood problem. Structural flood control such as levees and dam had been implemented to mitigate flood. Nowadays, the implementation of non-structural options such as flood modelling, early warning system and flood risk management has been given more attention worldwide to reduce the impact of flooding (Du, 2011).

Flood risk assessment consists of two main elements which are flood hazard and flood vulnerability. Flood hazard is normally illustrated in flood inundation or flood

extend maps, while flood vulnerability emphasizes the impact of flooding in flood damage map. In Malaysia, the study on flood vulnerability assessment is still limited especially on flood damage estimation. There are many methodologies for estimating the flood damage worldwide, however, there is no common methodology that is applied to estimate flood damage in Malaysia. Estimation of economic loss is essential to help the development of new housing away from the future flood disaster and reduce the damage loss. Therefore, with the aim to assist in the assessment of flood vulnerability, the purpose of this study is to assess the flood damage and to develop a residential flood depth-damage curve for Kuantan, Pahang. A relationship between flood damages and the local condition of the study area is obtained for future flood risk management planning.

1.2 Problem Statement

The east coast of Malaysia usually experiences a flood during the monsoon season. Kuantan is one of the cities that were affected since it is located at the east coast part of Malaysia. The unpredicted massive flood, recently in 2013 occurred due to prolonged heavy rainfall and land-use change brought serious risk to society, especially to low lying areas at Kuantan and Kemaman. Kuantan was severely distressed. Around 14,044 people were evacuated and major damages occurred in terms of electricity, road's structure, buildings, and belongings thus government suffered from the significant financial cost for repairing flood damages (Jamaludin et al., 2013).

Kuantan covers a large area of residential properties and have many different races and culture. There were many phases in Kuantan residential development thus Kuantan has different type of residentials from village house, terrace house, and bungalow house that is construct with different materials such as wood or brick. When the flood event occurs in 2013, several residentials in Kuantan has been hit by flood and the damage to each house may different according to house’s construction material.

Many flood hazard assessments had been done in Kuantan area to mitigate the risk of flooding. However, none flood vulnerability assessment is available. The main challenge in conducting the flood damage assessment is the insufficient of damage data. In many cases, floods occurred many years ago before the data is collected. This caused the data collected from the respondents to be quite inaccurate as some of the respondents were unable to recall exactly the flood durations and flood depth levels during the flood.

Hence, this study aims to assess the residential flood damages of 2013 Kuantan flood by collecting the flood information using face to face interview technique. The factors that effected the level of flood damage are investigated and at the end, a residential flood depth damage curve is established.

1.3 Objective

The objectives of this study are:

1. To assess the residential flood damages of 2013 Kuantan flood
2. To study the relationship between flood damages and socio-economic/ property characteristics of the study area
3. To establish a residential flood depth-damage curve for Kuantan

1.4 Limitation of study

This study is focusing on Kuantan River Basin. Kuantan district is in East Coast of Malaysia usually experience rain frequently at the end of the year. The Kuantan River Basin is an important watershed that crosses the state city of Pahang in Kuantan. It usually receives massive precipitation starting from November to March during the north-eastern monsoon season (Zaidi et al., 2014).

The estimation of flood damage was done by analysing the historical flood that occurred in Kuantan, limited for residential only. The study focusing on the estimation of direct tangible damage including the damage on building, furniture, plant and transportation. The damage is presented as economic losses such as the cost to repair or reconstruct the building, furniture and transportation. Also, the cost of the furniture that had been damaged.

1.5 Significant of study

The assessment of flood damage obtained from the field survey illustrated the damage experienced by the residents of Kuantan during the 2013 flood. The information is useful for further flood risk study in the study area. The factors that influenced the level of damage at the study area has been identified and will be given more priority in the future works. The main output of this study i.e. the flood depth damage curve presenting the association of flood damage and flood parameters of the study area. This curve is the

REFERENCES

Apel, H. and Thieken, A. H. (2013) 'Quantification of Uncertainties in Flood Risk Assessment', (June 2014). International Journal River Basin Management, Vol. 6, No. 2 (2008), pp. 149–162. doi: 10.1080/15715124.2008.9635344.

Dadson, S. J., Hall, W.J and Mutgatroyd, A. (2017) 'A Restatement of The Natural Science Evidence Concerning Catchment-Based 'Natural' Flood Management in The UK', Natural Flood Management, The Royal Society, p. 34.

Davis, S. A. and Skaggs, L. L. (1992) 'Catalog of Residential Depth-Damage Functions Used by The Army Corps Of Engineers in Flood Damage Estimation', (May 1992), p. 113. Available at: http://www.dtic.mil/dtic/tr/fulltext/u2/a255462.pdf.

DID (2009), Department of Irrigation and Drainage Malaysia. 'Flood Management Manual vol 1', DID Manual

Dias, P., Wagenaar, D., and Bouwer, L. (2018) 'Development of Damage Functions for Flood Risk Assessment in The City of Colombo (Sri Lanka)', Procedia Engineering. Elsevier B.V., 212, pp. 332–339. doi: 10.1016/j.proeng.2018.01.043.

DID (2000), 'Urban Storm Water Management Manual for Malaysia', Kuala Lumpur: Department of Irrigation and Drainage Malaysia

Diya, S. G., Barzanigasim, M. and EkhwanToriman, M. (2014) 'Floods in Malaysia Historical Reviews, Causes, Effects and Mitigations Approach', International Journal of Interdisciplinary Research and Innovations, 2(4), pp. 2348–1218.

Doocy, S., Daniels, A. and Murray, A. (2013) 'The Human Impact of Floods: a Historical Review of Events and Systematic Literature Review', PLOS Currents Disasters, 1, pp.1–32.doi: 10.1371/currents.dis.f4deb457904936b07c09daa98ee8171a.Authors.

Du, W. (2011) 'Systems and Methods for Flood Risk Assessment', Development of GIS-Based Flood Information System for Floodplain Modeling and Damage Calculation, Jun. 2000, Journal of the American Water Resources Association, vol. 36 No. 3, pp. 567-577. 1(12).

Hasanzadeh Nafari, R., Amadio, M. and Ngo, T. (2017) 'Flood Loss Modelling with FLF-IT: A New Flood Loss Function for Italian Residential Structures', Natural Hazards and Earth System Sciences, 17(7), pp. 1047–1059. doi: 10.5194/nhess-17-1047-2017.

Houston, D., Werrity, A., and Bassett, D., (2011) ‘Pluvial (Rain-Related) Flooding in Urban Areas: The Invisible Hazard’. Available at: http://www.jrf.org.uk/publications/pluvial-flooding-invisible-hazard.

Hua, A. K. (2014) ‘Monsoon Flood Disaster in Kota Bharu, Kelantan Case Study: A Comprehensive Review’, International Journal of Scientific Engineering and Research (IJSER) ISSN Online Impact Factor, 3(9), pp. 2347–3878. Available at: http://www.ijser.in/archives/v3i9/IJSER15479.pdf.

Jamaludin, M. H., S. Jaafar, B. K. Chuah, and Z. Abdullah. (2013). Flood : Kuantan Town Centre Almost Paralysed, 37,100 Evacuated in 4 States." New Straits Times. The New Straits Times Press (Malaysia) Berhad.

Lehman, W. and Nafari, R. H. (2016) ‘An Empirical , Functional Approach to Depth Damages’, 05002, pp. 1–8.

Mancusi, L., Albano, R., and Sole, A., (2016) 'Floodrisk: A QGIS Plugin for Flood Consequences Estimation', Geomatics Workbooks n° 12 – FOSS4G Europe Como 2015.

Marcus Ata, F., Khairul Amri Kamarudin, M., and Yaakub, N. (2018) ‘Impact of Hydrological Study to Water Quality Status in Kuantan River, Pahang, Malaysia’, International Journal of Engineering & Technology, 7(3.14), p. 35. doi: 10.14419/ijet.v7i3.14.16859.

Mcbean, E. (1987) ‘Flood Depth — Damage Curves by Interview Survey’, Journal of Water Resources Planning and Management, 9496(January 1987). doi: 10.1061/(ASCE)0733-9496(1988)114.

Merz, B., Kreibich, H., and Schwarze, R. (2010) ‘Review article “assessment of economic flood damage”’, Natural Hazards and Earth System Science, 10(8), pp. 1697–1724. doi: 10.5194/nhess-10-1697-2010.

Messner F., Penning-Rowsell E.C., Green C., Meyer V., Tunstall S., van der Veen A., 2007. 'Evaluating Flood Damages: Guidance and Recommendations on Principles And Methods', Integrated Flood Risk Analysis and Management Methodologies, FLOODsite Consortium, Wallingford, UK.

Meyer, V. and Messner, F. (2005) ‘National Flood Damage Evaluation Methods’, A Review of Applied Methods in England, the Netherlands, the Czech Republic and Germany pp. 1–49.

Mohamad, S., Aiyub, K. and Toriman, M. E. (2012) ‘Flash Flood and Community’s

Response at Sg. Lembing, Pahang', Advances in Natural and Applied Sciences, 6(1), pp. 19–25.

Mohammadi, S. A., Nazariha, M. and Mehrdadi, N. (2014) 'Flood Damage Estimate (Quantity), Using HEC-FDA Model. Case Study: The Neka River', Procedia Engineering, 70(June), pp. 1173–1182. doi: 10.1016/j.proeng.2014.02.130.

Notaro, V., Marchis, M., and Fontanazza, C. (2014) 'The Effect of Damage Functions on Urban Flood Damage Appraisal', Procedia Engineering. Elsevier B.V., 70, pp. 1251–1260. doi: 10.1016/j.proeng.2014.02.138.

Olesen, L., Löwe, R. and Nielsen, K. A. (2017) 'Flood Damage Assessment Literature Review and Recommended Procedure', Cooperative Research Centre for Water Sensitive Cities, Melbourne, Australia. doi: 10.5964/ejop.v11i1.829.

Pistrika, A. (2010) 'Flood Damage Estimation based on Flood Simulation Scenarios and a GIS Platform', European Water, 30, pp. 3–11.

Pistrika, A. K. and Jonkman, S. N. (2010) 'Damage to Residential Buildings due to Flooding of New Orleans after Hurricane Katrina', Natural Hazards, 54(2), pp. 413–434. doi: 10.1007/s11069-009-9476-y.

Pistrika, A., Tsakiris, G. and Nalbantis, I. (2014) 'Flood Depth-Damage Functions for Built Environment', Environmental Processes, 1(4), pp. 553–572. doi: 10.1007/s40710-014-0038-2.

Poussin, J. K., Botzen, W. J. W. and Aerts, J. C. J. H. (2014) 'Factors of Influence on Flood Damage Mitigation Behaviour by Households', Environmental Science and Policy. Elsevier Ltd, 40(June), pp. 69–77. doi: 10.1016/j.envsci.2014.01.013.

Romali, N. S., Yusop, Z. and Ismail, Z. (2018) 'Flood Risk Assessment : A Review of Flood', Jurnal Teknologi (April). doi: 10.11113/jt.v80.11189.

Roos, W. (2003) Damage to buildings. Delft Cluster report DC1-233-9. Samet J.M., Dominici F., Curriero F.C., Coursac I., Zeger S.L. (2000) Fine particulate air pollution and mortality in 20 U.S. Cities, 1987-1994, Th e New England Journal of Medicine Vol. 343 No. 24, pp. 1742-1749

Samsuri, N., Abu Bakar, R. and Unjah, T. (2018) 'Flash Flood Impact in Kuala Lumpur–Approach Review and Way Forward', International Journal of the Malay World and Civilisation , 6(Special Issue 1), pp. 69–76. doi: https://doi.org/10.17576/jatma-2018-06SI1-10.

Schröter (2014) 'How Useful Are Complex Flood Damage Models?', Water Resources Research, pp. 3378–3395. doi: 10.1002/2013WR014396.

Schueler, T. (1994) 'The Importance Of Imperviousness', Watershed protection techniques, 1(3): 100-111.

Solín, Ľ. and Skubinčan, P. (2013) 'Flood Risk Assessment and Management: Review of Concepts, Definitions and Methods', Geographical Journal 65 (2013) 1, 23-44.

Thieken, A., Merz, B., and Kreibich, H. (2006) 'Methods for Flood Risk Assessment: Concepts and Challenges', International Workshop on Flash Floods in Urban Areas, (September), pp. 1–12. Available at: http://www.rcuwm.org.ir/En/Events/Documents/Workshops/Articles/8/6.pdf.

Thieken, A., Muller, M., and Kreibich, H. (2005) 'Flood Damage and Influencing Factors: New Insights from The August 2002 Flood in Germany', Water Resources Research, 41(12), pp. 1–16. doi: 10.1029/2005WR004177.

Win, S., Zin, W., Kawasaki, A., and Zin Mar Lar Tin, S. (2018) 'Establishment of Flood Damage Function Models: A Case Study in The Bago River Basin, Myanmar', International Journal of Disaster Risk Reduction. Elsevier Ltd, 28(June 2017), pp. 688–700. doi: 10.1016/j.ijdrr.2018.01.030.

Zaidi, S. M., Akbari, A. and Ishak, W. M. F. (2014) 'A Critical review of Floods History in Kuantan River Basin : Challenges and Potential Solutions', International Journal of Civil Engineering

Zhou, Q., Mikkelsen, P. S., Halsnæs, K. and Arnbjerg- Nielsen, K. (2012) 'Framework for economic pluvial flood risk assessment considering climate change effects and adaptation benefits', Journal of Hydrology. Elsevier B.V., 414- 415, pp. 539–549. doi: 10.1016/j.jhydrol.2011.11.031.